Impact of Forest Management on Wood Quality of Southern Pine

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Using an hydraulic-powered wood borer to extract 12 mm cores from loblolly pine trees in order to analyze wood properties..

The South produces 15 % of the wood harvested in the world and 60 % of the wood harvested in the United States. Over 90% of the forested land in the South is owned by non-industrial landowners and industry. Private forest landowners face many challenges including changing environmental policies that will reduce the land available for wood production. As we move into the 21st century, more wood will need to be produced from fewer acres and a greater proportion of the softwood harvested from private lands will come from young, fast growing plantations.

The pressure to reduce rotation length in order to maximize return on investment has led to more reliance on intensively-managed plantations with practices that accelerate early growth of the trees. The pine pulpwood industry in the South now uses intensive cultural treatments such as vegetation control, fertilization, and planting of genetically improved seedlings to increase tree growth. The combined effect of these intensive environmental treatments is positive and significant: trees grow faster. Nevertheless, this faster growth affects lumber strength, stiffness, dimensional stability, pulp yields, and paper properties in ways that are not completely understood. We do know that intensively managed pines grow rapidly during the early years of the rotation, reach merchantable size at a younger age, and may contain a significantly higher proportion of juvenile wood. These effects raise the concern that the wood may not be optimal for use in traditional products.

Separating the effects of forest management, environmental factors, and genetics on wood properties is important to optimizing management of intensively-cultured plantations. The key is determining the amount and properties of juvenile wood. Juvenile wood is a cylinder of material surrounding the pith extending the length of all trees and is produced by young cambium in the live active crown. The faster a tree grows during the first few years of a rotation the larger the diameter of the juvenile core in the lower bole. Wood from young, fast growing pine plantations often has physical and mechanical properties that make it less desirable for traditional products such as structural lumber, panels, or paper. Juvenile wood has a higher proportion of earlywood-type tracheids and thus lower specific gravity, thinner cell walls, wider microfibril angles, and less latewood than mature wood. Because of the characteristics of its tracheids, juvenile wood has lower strength and stiffness, more longitudinal shrinkage, and less radial and tangential shrinkage than mature wood.the proportion of lumber downgraded because of drying defects. Structural lumber containing juvenile wood has significantly lower stiffness and lumber containing juvenile wood may not meet safety design specifications. Because of the high compaction of juvenile wood, it takes more juvenile wood to produce a composite panel compared to the amount of mature wood needed. Large volumes of juvenile wood in a mill's furnish

Wood sample being tested in static bending machine..

will result in composite panels with lower stiffness and lower dimensional stability than if the mill made panels from mature wood. Pulp yield is lower from juvenile wood than mature wood. Paper produced from juvenile wood pulp has good tensile, bust, fold and sheet smoothness but significantly lower tear strength and opacity.

Our unit conducts research on the effects of forest management and the environment on wood quality and tree growth of southern pine, mainly in partnership with industry and academia through the Wood Quality Consortium. The southern pine wood industry formed the Wood Quality Consortium in 1999 with our unit and the Warnell School of Forest Resources at the University of Georgia. The Consortium was originally formed with eight industrial members under a five-year agreement. The Consortium has just begun its second five-year contract and has grown to ten members. The director of the Consortium is Professor Richard F. Daniels; Alexander Clark of our unit serves as a co-director along with Laurence Schimleck, Assistant Professor at the Warnell School of Forest Resources.

The Consortium completed three large studies during the past five years: baseline, rotation age, and impacts of intensive forest management. The objective of the Baseline Study was to develop a comprehensive baseline of data for conventionally-managed planted loblolly pine across a matrix of conditions throughout the South, in order to determine the effects of environmental factors and stand variables on wood properties such as specific gravity, tracheid length, microfibril angle and their relationship with stiffness, strength and dimensional stability of wood. The objective of the Rotation Age Study was to determine the effect of geographic location, rotation age and rate of growth on plantation loblolly pine strength and stiffness. Baseline Study results show that specific gravity, which is directly correlated with lumber strength, stiffness and pulp yield, varies significantly across the range of planted loblolly pine. Results show that wood specific gravity is significantly higher in trees growing in the North Atlantic, South Atlantic and Gulf Coastal Plain compared to that of trees in the Piedmont or Hilly Coastal Plain. The trees in the Atlantic and Gulf Coastal Plain have a higher specific gravity because they produce a larger proportion of their annual ring in high specific gravity summer wood or latewood. Trees growing in the Atlantic and Gulf Coastal Plains produce more latewood because these regions have a longer growing season and receive more late summer precipitation than the Piedmont or Hilly Coastal Plain. Results of the Baseline study also show that length of juvenility, the number of years a tree produces juvenile wood at a fixed height, decreases from northwest to southeast across the loblolly pine range. In the Piedmont and Hilly Costal Plain the length of juvenility based on specific gravity averaged 9-11 years compared to 6-8 years in the Atlantic and Gulf Coastal Plains. Data collected in the Baseline study also show that microfibril angle (MFA) at breast height varies across the loblolly range. MFA decreases from wide MFA in the juvenile wood to low MFA of mature wood by age 9-10 in trees growing in the South Atlantic, Gulf and Hilly Coastal Plain, as compared to 12-20 years in the Piedmont and North Atlantic Coastal Plain. These regional differences in MFA are likely genetic and related to seed provenance.

Wood strength is highly correlated with wood specific gravity and increases with increased specific gravity. Wood stiffness is highly correlated with both specific gravity and MFA. Stiffness increases with increased specific gravity and also increases as MFA decreases. Thus, loblolly pine wood strength and stiffness vary from region to region across the south. Results of the Baseline and Rotation Age Studies show that clear wood from young planted loblolly pine growing in all regions has the strength or MOR to meet or exceed No. 2 and better dimension lumber design values but that juvenile wood and young mature wood from some regions fail to meet the stiffness or MOE specifications of No. 2 lumber. Results show that by age 15, trees in the South Atlantic Coastal Plain and Gulf Coastal Plain are producing wood with the stiffness required to meet No. 2 lumber stiffness specification. However, even at age 25 trees growing in the northern region of the North Atlantic Coastal Plain, Piedmont and Hilly Coastal Pain fail to produce wood with the stiffness required to meet the design specifications of No. 2 lumber. These preliminary results indicate that longer rotations may be required in the northern regions of the loblolly range to produce wood with required stiffness for lumber and engineered forest products.

The objective of the Impact of Intensive Forest Management on Wood Quality Study was to quantify the effects of competition control through herbicide application, fertilization in combination with competition control, and different levels of mid-rotation fertilization on basic wood properties and interactions with soils and geographic location. Results show woody plus herbaceous competition control significantly increased growth at all locations, did not significantly reduce ring specific gravity of earlywood or latewood, and did not significantly affect proportion of latewood in the annual ring. Woody plus herbaceous competition control did significantly increase

growth during juvenile wood formation in years 1 to 5 and thus increased the diameter of the juvenile wood core by an average of 19 percent over no competition control through age 15.

Nitrogen fertilization significantly increased annual growth for 3 to 5 years after application but specific gravity of earlywood and percent latewood were not significantly affected by the added nitrogen. However, the specific gravity of the latewood decreased significantly with increased application of nitrogen. Results of static bending tests show no significant reduction in wood strength or stiffness in trees receiving moderate amounts of added nitrogen (e.g., 100 or 200 lbs per acre) but the trees receiving 300 lbs per acre nitrogen produced wood with significantly lower strength and stiffness. High levels of N fertilization apparently stimulate rapid cell division and earlywood and latewood tracheid formation but not latewood secondary wall thickening. This reduces latewood specific gravity, strength and stiffness.